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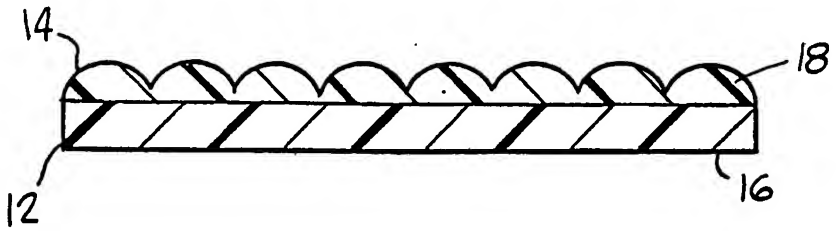

(57) Abstract

A method and apparatus for manufacturing a lenticular optical system and the lenticular optical system itself. A transparent or opaque substrate (12) is printed with a composite of lines to form one or more desired designs (16), and the substrate (12) is coated with a moldable material (18) that is molded with a set for grooves (14) parallel to the design lines, so that each design (16) is visible from certain viewing angles and not from other viewing angles. The moldable material (18) is preferably a quick-setting liquid such as ultraviolet-curable plastic which can be hardened almost immediately to allow fast production techniques.

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LENTICULAR OPTICAL SYSTEM

Field of the Invention

The present invention relates to the field of lenticular optics and, in particular, to the manufacture and use of lenticular optical systems in printed matter in which a lenticular lens overlays one or more composite designs so that the designs are visible or invisible depending on the viewing angle.

Background of the Invention

Lenticular lenses have been used for many years to produce interesting and useful optical effects. Typical lenticular lens systems include a transparent sheet of plastic or other material with a flat surface on one side and a set of parallel grooves on the other side. The grooves are roughly parabolic or semicircular in cross section so that each groove disperses light like a lens. On the flat side of the sheet is a design formed of a composite of lines. The lines of the design composite are positioned parallel to the grooves to take advantage of the light dispersion of the grooves. In this way, the design composite is visible from certain viewing angles but not from other viewing angles.

The system may employ one composite design or several depending on the desired effect. When only one design is used, the effect will be that the sheet shows the design from certain viewing angles but the sheet appears blank from other viewing angles. When more than one design is used, the effect will be that the sheet shows one design from certain viewing angles, another design from another viewing angle, and so on.

Lenticular optical systems are used in photographic applications, in television screens, for packaging, and for toys and novelties and other devices. Lenticular optical systems can also be used to create an image that appears to be three-dimensional, by using one composite design positioned

in relation to the parallel grooves such that it is visible to the left eye and a second composite design positioned in relation to the parallel grooves such that it is visible to the right eye.

The lenticular sheet may be mated with the design in several ways. One direct way is to simply print the design onto the flat side of the sheet. The design can then be covered with an opaque protective ink or other covering or can be left exposed for the transmission of light from behind the sheet through the flat side and out the grooved side. Another common way of mating the lenticular sheet with the design is to print the design onto a substrate and then adhere the sheet to the substrate. The substrate is commonly paper, but may also be a transparent or translucent material such as plastic to allow the transmission of light from the back of the lenticular sheet through the front. Yet another way of mating the lenticular sheet with the design is to apply the design to a substrate that is removable from the lenticular sheet and replaceable with another design, as shown in U.S. Patent No. 4,034,555 by Rosenthal, the contents of which are incorporated by reference.

A universal drawback to lenticular optical systems is the difficulty and cost of manufacturing the lenticular sheet and precisely mating the lenticular sheet with the designs so that the designs are viewable from the chosen viewing angles and only those angles. Lenticular sheets currently are manufactured using plastic extension techniques in which the groves of the sheet are produced by extruding the sheet through an extrusion die, using a grooved cylindrical die to form grooves onto the molten plastic by moving the sheet over the rotating cylinder, or using techniques involving hot stamping the grooves into stampable sheet

material such as PVC vinyl. Each of these approaches is somewhat costly, and still requires the additional step of producing the designs and precisely mating the lenticular sheet with the designs.

Summary of the Invention

The present invention includes an economical and effective system for using printing press techniques to produce a lenticular sheet and to mate the lenticular sheet with one or more designs. The designs are applied to a substrate, and then the substrate is emboss printed with a set of grooves to form the lenticular sheet using a transparent printable material. Preferably, the transparent printable material is quick-setting such as ultraviolet-curable plastic.

The substrate may be an ordinary paper or other substrate, or may be transparent such as a plastic sheet. If the substrate is paper or another common printing substrate, then the design would normally be printed on the side of the substrate that mates with the lenticular sheet that is applied to the substrate. If the substrate is transparent such as a plastic sheet, the substrate may be printed on either or both sides, with appropriate dimensional adjustments to the lenticular sheet and the composite lines of the design to produce the desired optical effect.

The system has the great advantage of providing a lenticular sheet that is economical and highly precise in its dimensions. Due to the very fast hardening of the quick-setting material, it can be manufactured in large quantities of sheets or rolls in a high speed process. In addition, by arranging the application of the lenticular sheet to the substrate in-line with the application of the design to the

substrate, the entire manufacturing process becomes streamlined, allows the product to be manufactured with a minimum of handling, and avoids the necessity for re-registering the design with the lenticular sheet.

Brief Description of the Drawings

FIG. 1 is a cross-sectional view of a lenticular sheet formed with a die cylinder in accordance with the present invention.

FIG. 2 is a diagrammatic view of a printing press for the present invention.

Detailed Description of the Invention

A cross-sectional view of a lenticular system in accordance with the present invention is shown in FIG. 1. The system includes a substrate 12 coated with a set of lenticular grooves 14. The substrate in a preferred embodiment is a transparent material such as transparent vinyl. The substrate may have a design applied to the side 16 away from the lenticular grooves. Alternatively, the design may be applied to the side 18 of the substrate to which the lenticular grooves are applied or designs may be applied to both sides 16 and 18. Whether the design is applied to one side or the other or both will dictate the substrate thickness and lenticular groove thickness and configuration that is required to obtain the desired optical properties, all in a manner well known in the art.

Although the preferred embodiment uses transparent vinyl as the substrate, it will be apparent that the substrate could also be an opaque material such as paper, provided that the design is then applied to the substrate side 18 that receives the lenticular grooves. The design itself is applied as a composite

of lines running parallel to the lenticular grooves in the manner known in the art, so that the lines of each design are visible from chosen viewing angles but not from other viewing angles. By alternating the composite of lines of more than one design, the system can achieve an optical effect in which one design is visible from certain viewing angles, and another design is visible from other viewing angles.

The coating of lenticular grooves 18 on the substrate is preferably a quick-setting transparent material such as ultraviolet-curable plastic. The material is applied directly to the substrate, the grooves are formed and the material is cured in the manner described below.

A diagram of a modified printing press used to apply the lenticular grooves to the substrate is shown in FIG. 2. The main elements of a common printing press 40 include a feed board 42 to feed the substrate toward the press, a gripper cylinder 44 which cooperates with an impression cylinder 46 to draw the substrate off the feed board and into the press, a blanket cylinder 48 to print the substrate and a cylinder 50 which cooperates with the impression cylinder 46 to draw the substrate out of the press and deposit it into a collector 54.

The press of FIG. 2 is modified from an ordinary press in that the blanket cylinder 48 has a die 49 with a set of grooves on the surface in the direction parallel to the longitudinal axis. The grooves are to apply the quick-setting lenticular material to the substrate in the desired grooved pattern. The lenticular material is metered through the inking rollers 58 and applied to the plate cylinder 60 in the ordinary manner, and is transferred from there to the blanket cylinder 48 for application to the

substrate. Once the material is applied to the substrate, it is hardened very quickly so that the substrate with applied lenticular material can be stacked or rolled. If the material is ultraviolet-hardening plastic, an ultraviolet light 64 is positioned on the side of the impression cylinder after embossing by the die on the blanket cylinder.

In a preferred embodiment, the substrate used is rigid polyvinylchloride, approximately .015 inches thick. The lenticular material is ultraviolet curable liquid and is applied to a thickness of .0025 inches at the top of the grooves and less than .001 inches at the bottom of the grooves. Of course, other materials and dimensions may be useful as well to accomplish the same result. The die applied to the blanket cylinder is made of magnesium or plastic which may be photopolymeric with grooves to match the grooves applied to the lenticular material.

In the embodiment described above, the lenticular material is applied in grooves to the substrate and the finished substrate is then stored for use later in printing composite designs onto the substrate. It is also possible to arrange the design printers in-line with the printer used for the lenticular material. In this manner, the system is manufactured in a single process so that there is no intermediate handling and storage step, and no need to re-register the substrate after the lenticular material is applied and before the substrate is printed with composite designs.

CLAIMS

1. A method for manufacturing a lenticular optical design, comprising coating a substrate with a liquid moldable material, and molding said material to form a plurality of parallel grooves.

2. The method of claims 1, further comprising applying a first design to the substrate, the first design being in a plurality of parallel spaced apart lines in the direction of the grooves in the material whereby the first design is substantially visible from certain viewing angles and substantially invisible from other viewing angles.

3. The method of claim 2, further comprising applying at least a second design to the substrate, the second design being in a plurality of parallel spaced apart lines in the direction of the grooves in the material, the lines of the second design being alternated with the lines of the first design in the direction perpendicular to the lines, whereby at least one design is substantially visible and at least one other design is substantially invisible from certain viewing angles and said at least one design is substantially invisible and said at least one other design is substantially visible from other viewing angles.

4. The method of claim 2, wherein said substrate is transparent and the design is applied to the side of the substrate opposite the side to which the moldable material is applied.

5. The method of claim 2, wherein said design is applied to the side of the substrate to which the moldable material is applied.

6. The method of claim 2, wherein the moldable material is molded with a rotating cylinder

having a die around the cylinder to mold the grooves.

7. The method of claim 6, wherein the moldable material is applied to the die and the die coats the substrate with the molded material.

8. The method of claim 7, wherein the moldable material is metered onto the die at a rate to produce a desired thickness of moldable material on the substrate.

9. The method of claim 2, wherein said moldable material is substantially hardenable by applying a hardening means, and further comprising substantially hardening the moldable material by applying said hardening means.

10. The method of claim 9, wherein the moldable material is plastic that is substantially hardenable by applying ultraviolet radiation.

11. The method of claim 2, wherein said substrate is coated with the moldable material by a moldable material applier and said design is applied by a design applier, the moldable material applier and design applier being positioned adjacent to one another so that the substrate can enter the one immediately after exiting the other without the need to store the substrate between the two applications.

12. The method of claim 11, wherein the design applier is a printing press.

13. An apparatus for manufacturing a lenticular optical design, comprising a cylinder having a die around the cylinder to mold a set of lenticular grooves in a direction parallel to the longitudinal axis of the cylinder and means for feeding a substrate into contact with the die for coating said substrate with the molded material.

14. The apparatus of claim 13, wherein said moldable material is a plastic hardenable upon

application of an ultraviolet light, and further comprising an ultraviolet light source to apply an ultraviolet light to the substrate with the moldable material applied thereto.

15. The apparatus of claim 14, further comprising means for applying a design to the substrate in a plurality of parallel spaced apart lines in the direction of said grooves whereby the design is substantially visible from certain viewing angles and substantially invisible from other viewing angles.

16. The apparatus of claim 15, wherein the design-applying means is a printing press.

17. A lenticular optional device, comprising a substrate, a grooved material coated onto the substrate, and a design applied to the substrate, the design having a plurality of parallel spaced apart lines in the direction of the grooves whereby the design is substantially visible from certain viewing angles and substantially invisible from other viewing angles.

18. The device of claim 17, wherein said material is a liquid plastic substantially hardened by application of ultraviolet light.

19. The device of claims 17, wherein the substrate is transparent.

20. The device of claim 17, wherein the substrate is opaque, and the design is applied to the side of the substrate that is coated with the grooved material.

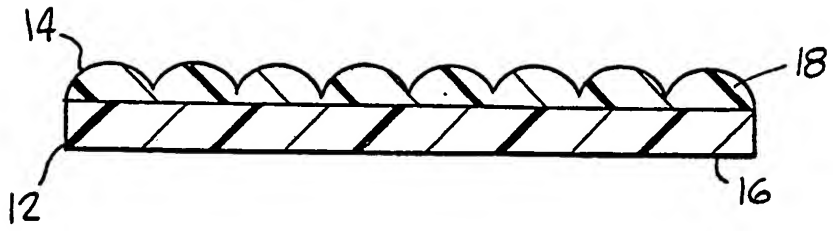

FIG.1

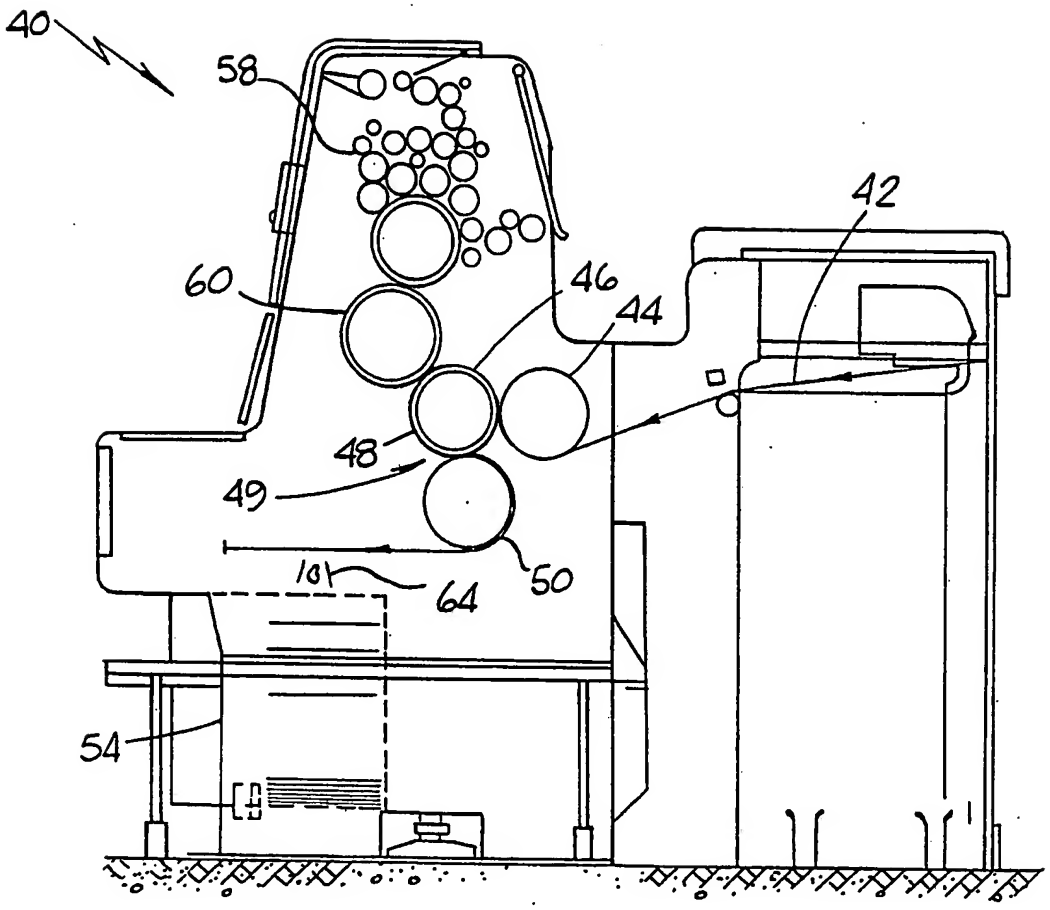

FIG.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/04479

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B32B 3/28; G02B 27/00; B29D 11/00; B05D 3/06
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 4,034,555 (ROSENTHAL) 12 JULY 1977. See the entire document.	1,2,4-10,17-20 3,11-16
X Y	US, A, 4,127,693 (LEMELSON) 28 NOVEMBER 1978. See the entire document.	1,2,4-10,17-20 3,11-16
X Y	US, A, 4,405,676 (POHL) 20 SEPTEMBER 1983. See the entire document.	1,2,4-10,17-20 3,11-16
X Y	US, A, 4,420,527 (CONLEY) 13 DECEMBER 1983. See the entire document.	1,2,4-10,17-20 3,11-16

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 4,414,316 (CONLEY) 08 NOVEMBER 1983. See the entire document.	1,2,4-10,17-20 3,11-16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/04479

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

101/16, 17, 28, 32;
264/1.6, 1.7, 1.9, 167, 241, 294;
354/101;
359/580, 619, 710;
425/402, 518, 520;
427/44, 162, 164;
428/141, 142, 167, 172, 187, 913

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

101/16, 17, 28, 32;
264/1.6, 1.7, 1.9, 167, 241, 294;
354/101;
359/580, 619, 710;
425/402, 518, 520;
427/44, 162, 164;
428/141, 142, 167, 172, 187, 913